THE OPEN UNIVERSITY OF SRI LANKA
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
BACHELOR OF TECHNOLOGY
ECX5238-HIGH VOLTAGE ENGINEERING AND ELECTRICAL MACHINES
FINAL EXAMINATION - 2015/2016   CLOSED BOOK

Date: 15th December 2016   Time: 0930-1230

Instructions to candidates: Answer any *five (05)* questions. Select at least *one* question from section **B**. Graph papers will be available on your request.

Permeability of free space μ_0 = 4π x 10^{-7} H/m   Permittivity of free space ε_0 = 8.854 x 10^{-12} F/m

Section A: High Voltage Engineering

Q1.

a) State two advantages and disadvantages of using bundled conductors for high voltage power transmission.

[5 marks]

b) By deriving from first principles, show that the electric stress in a single core cable is not uniform.

[5 marks]

c) A single phase capacitance graded cable has a conductor diameter of 10 mm and an outer (sheath) diameter of 50 mm. The inner insulation layer has a relative permittivity of 4 and a peak dielectric strength of 6 kV/mm. The outer sheath has a relative permittivity of 2.5 and a peak dielectric strength of 5 kV/mm. Calculate the maximum working voltage (rms) for the cable.

[10 marks]

Q2.

a) Describe briefly with the aid of suitable diagrams, where appropriate, the following:

   i. Time lag characteristic of spark breakdown for a standard impulse waveform.

[4 marks]

   ii. Thermal breakdown of a solid dielectric.

[3 marks]

   iii. Breakdown of solid insulating materials due to internal discharges

[3 marks]

   iv. Breakdown of liquids below intrinsic strength due to the 3 types of impurities.

[4 marks]

b) A 132 kV, three-phase, 50Hz transmission line uses 18 mm diameter, equally spaced ACSR conductors. What should be the spacing between these conductors, if it is to be designed such that the corona inception voltage is 5% higher than the normal operating voltage of the line at normal temperature and pressure conditions.

[6 marks]

Q3.

a) Describe briefly with the aid of suitable diagrams, one form of electrostatic generator used to obtain high direct voltages.

[4 marks]

b) Give the basic circuit and explain briefly a resonance method used to control the output of a high voltage test transformer.

[4 marks]

Why is this method not suitable for power transmission?

[2 marks]

c) Show that the deflecting torque of an electrostatic voltmeter is proportional to the product of the square of the applied voltage and the rate of change of capacitance.

[4 marks]

d) Outline the significance of type tests, sample tests and routine tests performed on high voltage equipment, making use of suitable examples.

[6 marks]

Q4.

a) Figure Q4 shows a modified form of High Voltage Schering Bridge used in a particular measurement. The values of the components at balance are shown on the diagram. Determine the value of the unknown capacitor and its loss tangent.

[12 marks]

b) It is later detected that the standard capacitor used is not lossless, but has a loss factor of 0.0014. What are the actual values of the unknown capacitor and loss tangent?
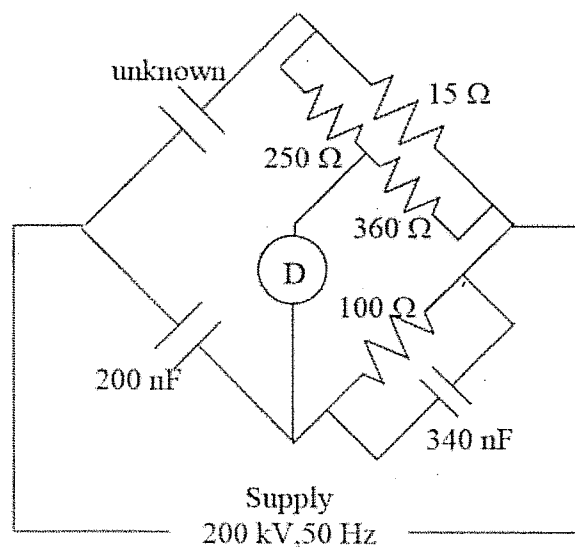
[8 marks]

Figure Q4

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Section B: Electrical Machines

Q1.

a) Calculate the basic step angle for the following stepper motors?

    i. 8/6 , 4 phase VR steppers
    ii. 12/8, 3 phase VR steppers
    iii. 8/72, 4 phase multi-stack motor
    iv. 4/9 pole , 2 phase, PM hybrid motor

[8 marks]

b) Sketch typical pullout-torque versus stepping-rate characteristics for a stepper motor and give step responses in the modes of multi-step and slewing.

[7 marks]

c) What do you mean by the terms start rate and stop rate?

[5 marks]

Q2.

a) An 11 kV star connected 3 phase synchronous motor works at constant voltage and constant excitation. Its synchronous impedance is $1.8 + j15\Omega$ per phase. When the input power is 1200 kW, the observed power factor is at 0.8 leading. Find the operating power factor when the input is increased to 1500 kW.

[10 marks]

b) A 75 MVA, 12.5 kV salient pole synchronous machine has direct axis and quadratic reactances of 2.6 Ω and 1.7 Ω respectively. Armature resistance is neglected. Determine induced EMF when the machine delivers rated power at 0.85 power factor lagging.

[10 marks]

Q3.

a) A three phase, 415 V, 100 kW, 50 Hz four pole induction machine delivers the rated power at a slip of 0.04. The ratio of number of turns on the stator winding to that on the rotor is 1: 0.5 and both windings are star connected. Determine:

    i. The synchronous speed and the motor speed.
    ii. Frequency of the rotor current.
    iii. The speed in rpm.
    iv. The torque on the rotor shaft.
    v. The voltage induced on the rotor winding

[15 marks]

b) With the aid of a circuit diagram and a voltage waveform, discuss the meaning of DC choppers. Express the average load voltage and current in terms of switching frequency, the source voltage and the source current respectively.

[5 marks]